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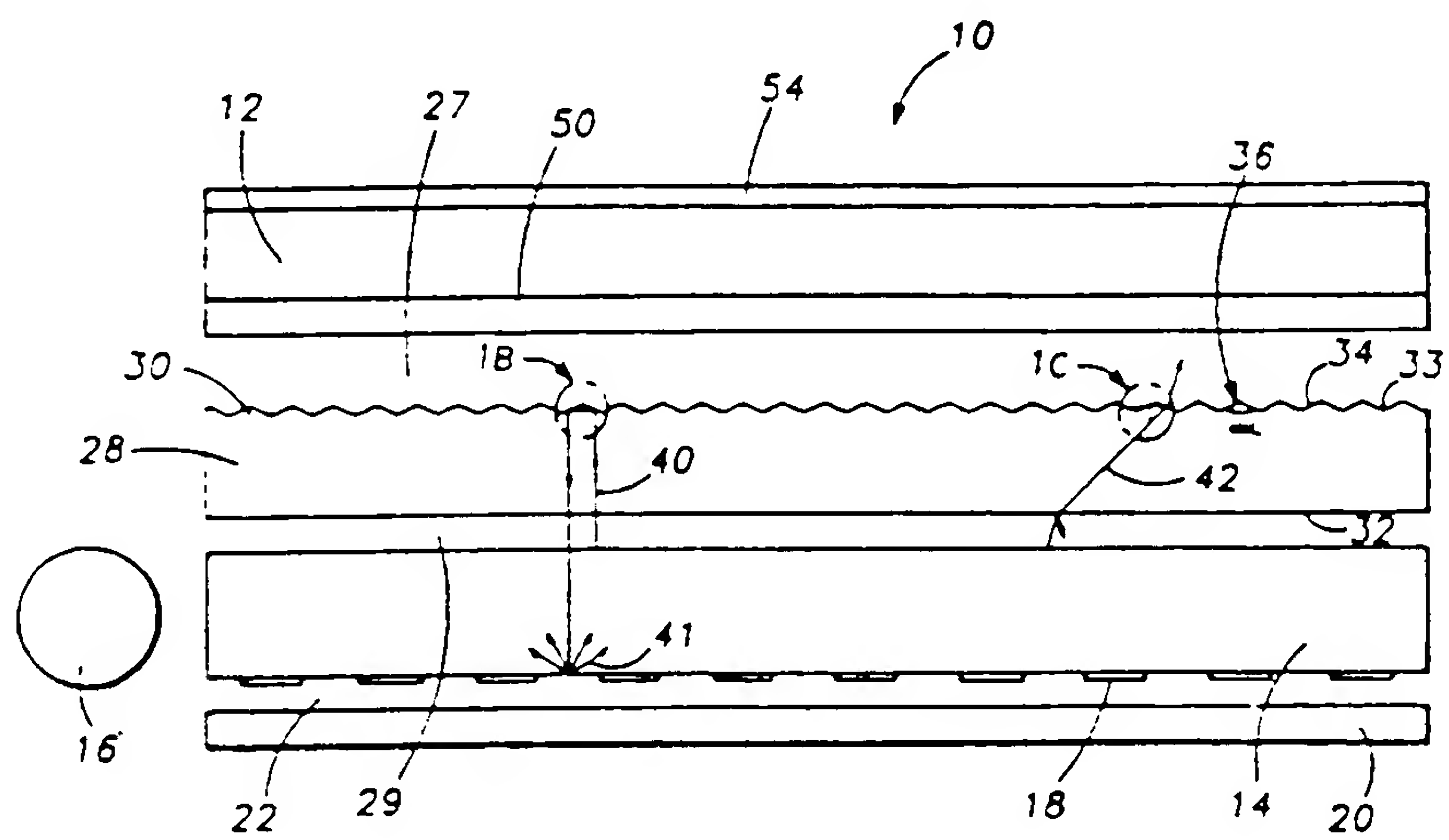

(57) Abstract

...ear polarizing layer extending across the rear surface of the display and an illumination source spaced from the polarizing layer ... brightness enhancing layer disposed between the polarizing layer and the illumination source has a preferred polarization axis, transmitting more light polarized in one direction than another. The brightness increasing layer is oriented with the preferred polarization axis substantially aligned with the transmission axis of the polarizing layer. The method includes the steps of providing a liquid crystal display, positioning a linear polarizing layer proximate the rear surface of the display and illuminating the display with a light source spaced from the polarizing layer. A prismatic film which has a preferred polarization axis and transmits a partially polarized output is positioned between the polarizing layer and the light source. The method further includes the step of orienting the prismatic film with the preferred polarization axis substantially aligned with the transmission axis of the polarizing layer.

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LIQUID CRYSTAL DISPLAY WITH ENHANCED BRIGHTNESS

The present invention relates generally to liquid crystal displays (LCD's) used in such applications as computer displays, calculators, electronic watches and the like, and particularly to apparatus for increasing the brightness of the images displayed by backlit LCD's without increasing the amount of power used by the backlight.

Background of the Invention

Backlit LCD's may be used in applications which require moderately low power consumption, but in which the available ambient light may not be sufficient to enable viewing of the LCD. For instance, LCD computer monitors are typically backlit.

A backlit LCD often includes a light pipe or thin transparent sheet of material extending across the back surface of the LCD. A light source, such as a fluorescent lamp, is positioned adjacent an edge of the light pipe. Light is piped through the transparent sheet and evenly distributed across the pipe surface to illuminate the LCD. A linear dichroic polarizer disposed between the LCD and the light pipe filters the randomly polarized light, transmitting only light polarized parallel to the transmission axis of the polarizer. The light emerging from the light pipe has a random polarization; that is, there is light with all possible polarization axes. The linear dichroic polarizer transmits the portion of the light having a polarization parallel to the transmission axis of the polarizer. A second linear dichroic polarizer extends across the front of the LCD. The two polarizers, which may have different orientations, cooperate to maximize the transmission difference between selected and unselected areas of the LCD's.

A well known problem with backlit LCD's, however, is that the LCD may not be clearly legible under all environmental conditions. The ambient light in some environments may be particularly bright, reducing the distinctiveness of the selected areas of the LCD.

energy supplied by the battery is used to backlight the back side of the display. Thus, sufficiently illuminating the display substantially reduces the usable life of the battery between recharges. An LCD which is not bright enough interferes with an operator's ability

to utilize the application incorporating the LCD since the displayed images are not clearly legible. Furthermore, attempting to read an LCD over a period of time under these conditions may have a detrimental affect on the physical condition of the operator, significantly reducing the operator's efficiency.

For randomly polarized light fifty percent of the light emitted by the light pipe has a polarization axis parallel to the transmission axis of the linear dichroic polarizer behind the LCD. Thus, the light supplied by the backlighting assembly is not efficiently used. The brightness of the LCD may be increased by increasing the output of the lamp. In many applications, particularly portable laptop computers, this is not desirable as it increases the amount of power used to operate the total device. Increasing the amount of available light which may actually be used to illuminate the back of the LCD would also increase the brightness of the display.

In some applications, a prismatic film is positioned between the light pipe and the back surface of the LCD to increase the brightness of the light emitted by the light pipe. The prismatic film reflects light, by Total Internal Reflection (TIR), incident at angles which are within a specific range normal to the film plane and refracts light incident at angles outside of that range. A small percentage of light emitted by the light pipe is also reflected at the air/film surface interfaces. The light reflected back towards the light pipe is scattered off its rear white reflector and is redirected towards the prismatic film. The light is then either refracted through the film or reflected back towards the light pipe, depending upon the angle of incidence to the prismatic film of the particular ray. Using the prismatic film to recycle the light emitted by the light pipe may increase the usable light intensity by 50% or more.

The images displayed on a backlit LCD having a prismatic layer between the LCD and the light pipe are somewhat brighter than those on a standard backlit LCD. However, a problem with these backlit LCD's is that even with increased brightness, in some applications the displayed images may not be sufficiently clear and distinct. The backlighting assembly is not efficient, since approximately 50% of the light is absorbed by the linear dichroic polarizer. Much of the light intensity provided by the combined light pipe and prismatic layer is still lost.

A primary object of the present invention, therefore, is to provide a backlit LCD assembly which more efficiently uses the available light to increase the brightness of the displayed images.

Another object of the present invention is to provide a backlighting assembly for an LCD which substantially increases the brightness of images displayed on the LCD.

A further object of the present invention is to provide a backlit LCD assembly in which the displayed images are clear and legible in most environmental conditions.

A more general object of the present invention is to provide a backlit LCD assembly which may be economically manufactured.

Summary of the Invention

In summary, the present invention is an LCD assembly with a backlighting apparatus which substantially increases the brightness of the displayed images. The LCD assembly includes an LCD and a light source spaced from the rear surface of the LCD. A linear polarizing layer extends across the rear surface of the LCD. Light polarized parallel to the polarization axis is transmitted by the linear polarizing layer. A brightness increasing layer disposed between the polarizing layer and the light source has a preferred polarization axis in that the transmitted output has more light polarized in one direction (the preferred polarization) than another. The brightness enhancing layer and the linear polarizing layer are oriented with the preferred polarization axis of the brightness increasing layer and the transmission axis of the polarizing layer aligned, providing for maximum light transmission and increasing the display brightness of the LCD.

The present invention also provides a method for enhancing the brightness of an LCD which includes the steps of providing an LCD, positioning a linear polarizing layer proximate the rear surface of the LCD and illuminating the LCD with a light source spaced from the linear polarizing layer. A prismatic film is positioned between the light source and the polarizing layer. The prismatic film produces an output that is partially polarized, with more light polarized in one direction than another, such that the film has a preferred polarization axis. The film is oriented with the preferred polarization axis substantially aligned with the transmission axis of the polarizing layer.

Brief Description of the Drawings

Additional objects and features of the invention will be [illegible]

[illegible] drawings, in which:

Figure 1 is an end view of an LCD assembly in accordance with the present invention.

Figure 1A is an enlarged fragmentary view of the area within the dashed line 1A in Figure 1.

Figure 1B is an enlarged fragmentary view of the area within the dashed line 1B in Figure 1.

Figure 2 is an enlarged top view of the prismatic film and linear dichroic polarizer of the LCD assembly of Figure 1.

Figure 3 is a table showing the light transmission and gain for various prismatic materials.

Figure 4 is a cross sectional view of another embodiment of an LCD assembly in accordance with the present invention.

Description of the Preferred Embodiment

Referring to Figure 1, there is shown an LCD assembly 10 constructed in accordance with the present invention. The assembly 10 generally includes a backlit LCD 12 which is illuminated by means of a light pipe 14. The light pipe 14 is provided by a thin sheet of transparent material of substantially the same size as the LCD. A light source, such as a small diameter cold cathode fluorescent lamp 16, extends along an edge of the transparent sheet and provides the light for illuminating the display 12. Light travels from the light source into the light pipe 14, which transmits the light from the source 16 by Total Internal Reflection (TIR), with the light being internally reflected along the length of the pipe. A plurality of diffuse dots 18 of low loss white pigment are imprinted on a surface of the light pipe to produce a substantially Lambertian distribution of light. In the present embodiment, the pigment is applied to the lower surface of the light pipe; however, the dots may also be provided on the upper surface. Some of the light striking one of the diffuse dots 18 will exit the light pipe and illuminate the LCD. The light leaving the light pipe 14 has an essentially random polarization; that is, the polarization axes of the rays of light leaving the light pipe are oriented in all directions. As light exits the light pipe, the intensity of the remaining light is reduced. The density of the diffuse dots increases in relation to the distance separating the dot 18 from the light source 16 to compensate for the reduction in light intensity.

A reflector 20 is provided below the light pipe 14 to reflect light emitted from the bottom surface of the light pipe towards the LCD 12 so that substantially all of the light released from the light pipe is directed towards the LCD. An air space 22 separates the reflector 20 from the lower surface of the light pipe since the reflector is not laminated or optically coupled to the light pipe 14. If laminated to the light pipe, the reflector would extract the internally reflected light from the light pipe. The reflector 20 is preferably

a non-specular or diffuse reflector to provide the reflected light with a substantially random polarization and direction. However, a specular-type reflector 24 may be substituted for the non-specular reflector 20 as is shown in Figure 4. Polarized light reflected by the specular-type reflector 24 is generally not substantially depolarized. A diffusing layer 25 is positioned above the light pipe 14 to ensure that the provided light has both random polarization and direction. A diffusing layer may also be used with a non-specular reflector to conceal the diffuse dots 18.

A prismatic film 28 is disposed between the LCD 12 and the light pipe 14 for enhancing the brightness of the images displayed on the LCD. Since the prismatic film is not laminated or optically coupled to either the LCD or the light pipe 14, air spaces 27 and 29 separate the prismatic film 28 from the light pipe and the LCD. The air spaces preserve the optical characteristics of light entering and leaving the film, preventing light from escaping in unwanted directions. The film 28 includes a faceted surface 30 facing the back of the LCD and a substantially smooth or glossy surface 32 opposite the light pipe 14. Light emitted by the light pipe assembly is refracted by the smooth surface 32 and intersects faceted surface 30. The faceted surface is formed with a plurality of grooves 33 defined by facets 34 of adjacent prisms 36. The facets 34 of each prism 36 are separated by a prism angle α. A smooth surface 32 is preferred over a rough or scattering back surface which would increase the angles of light within the film and spread the output further, thereby reducing the display brightness.

In the present embodiment, the prismatic film is constructed of a material having an index of refraction substantially greater than 1.0 and preferably greater than 1.41, providing for total internal reflection of light intersecting the faceted surface at an angle (θ) greater than the critical angle (θ_c) for the selected material. As is shown particularly in Figures 1 and 1A, a portion of light generally designated by rays 40 is reflected back towards the light pipe 14. The light ray 40 intersects one of the facets 34 at an angle $\theta > \theta_c$ and is internally reflected. The reflected ray 40 intersects an adjacent facet 34 at an angle $\theta > \theta_c$, where it is totally reflected towards the light pipe 14. The reflected light

[illegible] both the polarization and direction. The scattered light, indicated generally at 41, travels through the light pipe 14 and re-enters the prismatic film 28. If any rays of the scattered light 41 intersect the facets 34 at an angle $\theta > \theta_c$, the rays will again be totally internally reflected and redirected towards the reflector 20. Although not shown,

some of the light will also be reflected by the air/film interface at the smooth surface 32 of the prismatic film.

A portion of the light entering the prismatic film, generally designated by rays 42, intersects one of the facets 34 of the faceted surface at an angle $\theta < \theta_c$ as is shown in Figures 1 and 1B. A portion of the light designated by ray 42 is refracted towards the LCD 12, while the remainder of the light is directed through the prism 36 towards another facet 34. Light intersecting the facet 34 is split, with a portion being reflected towards the light pipe and the remainder passing into the prismatic film. The light reentering the film will either be reflected or refracted, depending upon the angle at which the light intersects the interior of the faceted surface 30. A ray striking the smooth surface 32 at an angle is also refracted, as is shown by ray 42 in Figure 1, with a portion being directed towards the faceted surface and the remainder being reflected towards the light pipe.

The faceted surface 30 tends to normalize the direction of the refracted light relative to the prismatic film 28. Light having a substantially normal orientation, preferably within the range of $\pm 30°$ horizontally and $\pm 15°$ vertically from a normal axis, is an optimum range for viewing the LCD. The refracted light is concentrated into a zone which extends outward from an axis normal to the film to ensure that a major portion of the transmitted light falls within an optimum range. The area over which the concentrated zone extends depends upon the index of refraction of the film and the prism angle α. In the present embodiment, the film is a polycarbonate material having a nominal index of refraction of 1.586 and the prism angle is 90°. The zone into which the light is concentrated is within the range of approximately $\pm 55°$ in a direction parallel to the grooves 33 and approximately $\pm 35°$ in a direction perpendicular to the grooves. Increasing the prism angle α increases the area of the zone of concentration, while a smaller prism angle concentrates the light into a narrower zone. However, a prism angle of 90° is preferred as the total reflectance of light from a Lambertian source is maximized at this angle, providing more light to be recycled, thereby enhancing brightness. With angles smaller than 90°, the potential gain is reduced and more light escapes at uncontrolled angles.

The electric vector of polarized light may be resolved into components of polarization parallel to and perpendicular to the plane of incidence (i.e. the plane defined by the incident ray, such as the light designated by rays 40 and 42, striking the facet 34 and an axis normal to the facet 34). A higher percentage of light reflected by the prismatic film 28 has a polarization perpendicular to the plane of incidence, resulting in more of the transmitted

light having a polarization axis parallel to the plane of incidence. Thus, the output transmitted by the film is partially polarized, with the polarization axis of peak intensity being parallel to the plane of incidence. The transmission of a partially polarized output provides the prismatic film with a preferred polarization axis 46 which is parallel to the polarization axis of peak intensity, or in other words parallel to plane of incidence. In the preferred embodiment the polarization axis of peak intensity, and therefore the preferred polarization axis 46 of the film, is perpendicular to the grooves 33.

The non-specular reflector 20 (Figure 1) or the specular-type reflector 24 and diffusing layer 25 (Figure 4) scatter and depolarize the reflected light so that the reflected light again has a random polarization, with approximately 50% polarized perpendicular to the plane of incidence, therefore light entering the back surface of the prismatic film has a substantially random polarization. Light entering the prismatic film at an angle may be slightly polarized due to the exit angle from the previous layer. For example, when a very diffuse translucent (low absorbance) sheet is used for the diffusing layer, light exiting the diffuse sheet at 30.25° from a normal axis has been found to have a ratio of light polarized parallel to the plane of incidence to light polarized perpendicular to the plane of incidence of 1.03.

Increasing the index of refraction of the prismatic film will, at a given incident angle, increase the amount of light polarized perpendicular to the maximum intensity axis 46 that is reflected by the prismatic film. The polarization effect is dependent upon the angle of incidence and the refractive index. Increasing the percentage of the reflected light which is polarized perpendicular to the plane of incidence will provide a greater polarization effect; that is, more of the transmitted light will have a polarization axis parallel to the plane of incidence, increasing the peak intensity. The polycarbonate film used in the present embodiment has a high index of refraction (n=1.586). Examples of other thermoplastic polymeric film materials include, but are not limited to, acrylics, polystyrenes and thermoplastic polyesters. The prismatic film may also be a composite construction of a [illegible]

[illegible] 90° isosceles prisms. The grooves 33 have a width of .002 inch extending between the peaks of the adjacent prisms 36. The 90° prisms and the high index of refraction maximize the polarization effect of the film 28

Figure 3 shows theoretical light transmission and gain calculated for prismatic films having selected prism angles α (called the "included angle" in Figure 3) and indices of refraction, assuming a "perfect" backlight having no losses and ignoring the polarization effect. $T_\perp$ refers to transmission for a normally exiting ray of light polarized perpendicular to the grooves 33, while $T_\parallel$ refers to transmission of light polarized parallel to the grooves 33. The $T_\perp/T_\parallel$ ratio shows that more of the transmitted light is polarized perpendicular to the grooves 33, or parallel to the preferred polarization axis of the film. Similarly, the calculated values for $Gain_\perp$ (light polarized perpendicular to the grooves or parallel to the preferred polarization axis) are greater than the $Gain_\parallel$ (parallel to the grooves).

The LCD assembly 10 further includes a polarizing layer, such as linear dichroic polarizer 50, extending across the back surface of the LCD. The linear dichroic polarizer 50 has a transmission axis 52 such that light of one polarization, that polarized parallel to the axis 52, is transmitted and used to illuminate the LCD. Light polarized perpendicular to the transmission axis 52 is blocked or substantially absorbed by the polarizer. A second polarizing layer or linear dichroic polarizer 54 extends across the front surface of the LCD 12. The polarizers 50 and 54 cooperate to provide a maximum difference in transmission between the selected and unselected areas of the LCD 12.

The polarizer 50 and the film 28 are oriented relative to one another with the preferred polarization axis 46 of the film substantially aligned with the transmission axis 52 of the polarizer. In other words, the film 28 is positioned with the grooves 33 extending in a direction substantially orthogonal to the transmission axis of the polarizer. This configuration maximizes the amount of light transmitted by the film 28 which is available for illuminating the display. When the axes 46 and 52 are not completely aligned, the amount of polarized light transmitted will be reduced by a factor proportional to $\cos^2\theta$, where θ represents the angle between the polarization axis 52 and the maximum intensity axis 46. For example, with a 30° misalignment, the amount of polarized light transmitted will be reduced by 25% of the polarized light transmitted with the axes completely aligned.

As discussed above, the light entering the prismatic film may have a slight polarization when a diffuser is positioned between the light pipe 14 and the film 28, for example a ratio of 1.03 at an angle of 30.25° to a normal axis. For a polycarbonate film ($n=1.586$) with a prismatic angle of 90°, the resulting effect was found to be about 13% greater with the axes 46 and 52 aligned than when the axes are orthogonal. For light exiting the diffuser at an angle of 40° and 50° relative to a corresponding display angle of 10.2° and 18.9°

with an axis normal to the display, the brightness was found to be about 17% and 24% greater, respectively, with the axes aligned than when the axes are orthogonal. Thus, by aligning the preferred polarization axis 46 with the transmission axis 52 of the polarizer, the brightness of the LCD is substantially increased.

Aligning the maximum intensity axis and the polarization axis of the polarizer produces a theoretical gain of approximately 100% over the brightness of an LCD assembly without the prismatic film, and a gain of 11% over an assembly having a prismatic film and diffuser where the maximum intensity axis is skewed 90° relative to the polarization axis of the polarizer. The output produced by the film is concentrated into a limited zone surrounding the optimum viewing range. With the LCD assembly of the present invention, the brightness of images displayed on the LCD is increased by maximizing the amount of light which is available for illuminating the LCD.

While the present invention has been described with reference to a few specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A liquid crystal display assembly comprising:

a liquid crystal display having a front display surface and a back surface;

means for illuminating said display, said illuminating means including a light source spaced from said rear surface of said display;

a polarizing layer extending across said rear surface of said display and having a transmission axis, said polarizing layer transmitting light polarized parallel to said transmission axis; and

brightness increasing means disposed between said polarizing layer and said light source, said brightness increasing means receiving light from said light source and transmitting a partially polarized output, said brightness increasing means having a preferred polarization axis along which the partially polarized output has a peak intensity, which brightness increasing means is oriented relative to said polarizing layer with said preferred polarization axis substantially aligned with said transmission axis of said polarizing layer.

2. The assembly of claim 1 wherein,

said brightness increasing means includes a polymeric film having a faceted surface with a plurality of substantially symmetrical facets formed thereon.

3. The assembly of claim 2 wherein,

said faceted surface is formed with a plurality of 90° isosceles prisms.

4. The assembly of claim 1 wherein,

said brightness increasing means includes a prismatic layer having a faceted surface formed for increasing the intensity of the output polarized parallel to said preferred polarization axis.

5. The assembly of claim 1 wherein,

said brightness increasing means includes a faceted surface formed with a plurality of facets, said facets defining a plurality of parallel grooves extending in a direction perpendicular to said preferred polarization axis, said brightness increasing means being

oriented relative to said polarizing layer with said grooves substantially orthogonal to said transmission axis of said polarizing layer.

6. The assembly of claim 1 wherein,

said illuminating means includes light reflective means, said brightness increasing means reflecting a portion of light received from said light source towards said light reflective means, said light reflective means scattering the reflected light towards said brightness increasing means, the scattered light having a random polarization.

7. The assembly of claim 6 wherein,

said light reflective means comprises a reflective layer spaced from said brightness enhancing means and a diffusing layer disposed between said brightness enhancing means and said reflective layer.

8. The assembly of claim 6 wherein,

said light reflective means comprises a non-specular reflective layer.

9. The assembly of claim 1 wherein,

said brightness increasing means refracts a portion of light received from said illuminating means and reflects a substantial portion of the remainder of the light received from said illuminating means, said brightness increasing means concentrating the refracted light into a limited zone extending outward from an axis normal to said brightness increasing means.

10. The assembly of claim 9 wherein,

said brightness increasing means concentrates the refracted light into a limited zone substantially within the range of $\pm 55°$ with the normal axis in a direction perpendicular to said preferred polarization [illegible]

[illegible]

11. The assembly of claim 1 wherein,

said brightness increasing means comprises a thermoplastic polymeric film having an index of refraction substantially greater than [illegible]

12. The assembly of claim 11 wherein,

said polymeric film is one of a polycarbonate, an acrylate, a polystyrene, a thermoplastic polyester and a composite of a base film and a UV-cured second layer having microstructured prisms.

13. A liquid crystal display assembly comprising:

a liquid crystal display having a front display surface and a rear surface;

means for illuminating said display, said illuminating means including a light source spaced from said rear surface of said display;

a linear polarizing layer positioned proximate said rear surface of said display and having a transmission axis, said polarizing layer transmitting light polarized parallel to said transmission axis and obstructing a major portion of light polarized perpendicular to said transmission axis; and

a prismatic layer extending between said light source and said polarizing layer, said prismatic layer having a faceted surface facing said polarizing layer and a back surface opposite said light source, said prismatic layer receiving light from said light source and transmitting a partially polarized output, said prismatic layer having a preferred polarization axis along which the partially polarized light has a peak intensity, said prismatic layer being positioned with said preferred polarization axis substantially aligned with said transmission axis of said polarizing layer.

14. The assembly of claim 13 wherein,

said prismatic layer refracts a portion of light received from said illuminating means into a predetermined zone extending outward from an axis normal to said faceted surface.

15. The assembly of claim 13 wherein,

said illuminating means includes light reflective means spaced from said back surface of said prismatic layer; and

said prismatic layer reflects a portion of the received light towards said light reflective means, said light reflective means scattering the reflected light towards said prismatic layer.

16. The assembly of claim 13 wherein,

said rear surface of said prismatic layer is substantially smooth.

17. The assembly of claim 13 wherein,

said prismatic layer comprises a substantially transparent polymeric film having a plurality of facets defining a plurality of parallel grooves, said grooves extending across said faceted surface in a direction perpendicular to said preferred polarization axis.

18. The assembly of claim 13 wherein,

said illuminating means includes a lamp, and

said light source comprises a light pipe having a planar surface opposite said polarizing layer and a peripheral edge adjacent said lamp, said light pipe receiving light from said lamp and distributing the received light through said planar surface.

19. A method for enhancing the brightness of a liquid crystal display comprising the steps of:

providing a liquid crystal display having a front display surface and a back surface;

positioning a polarizing layer having a transmission axis proximate said rear surface of said display, said polarizing layer transmitting light polarized parallel to said transmission axis and obstructing a major portion of light polarized perpendicular to said transmission axis;

illuminating said liquid crystal display with a light source spaced from said polarizing layer;

positioning a prismatic film between said light source and said polarizing layer, said prismatic film receiving light from said light source and transmitting a partially polarized output, said prismatic film having a preferred polarization axis along which the partially polarized output has a peak intensity; and

orienting said prismatic film with said preferred polarization axis substantially aligned with said transmission axis of said polarizing layer.

20 The method of claim 19 [illegible]

[illegible] said polarizing

[illegible] includes selecting a prismatic film maximizing the intensity of the partially polarized output along said preferred polarization axis.

[illegible] The method of claim 20 wherein,

said step of selecting a prismatic film includes selecting a prismatic film which refracts a portion of the received light and reflects a substantial portion of the remainder of the received light, said prismatic film concentrating the refracted light into a limited zone extending outward from an axis normal to said prismatic film.

22. The method of claim 20 wherein,

said step of illuminating said liquid crystal display includes positioning light reflective means adjacent said light source, and

said step of selecting a prismatic film includes selecting a prismatic film which reflects a portion of the received light towards said light reflective means, said light reflective means scattering the reflected light towards said prismatic film.

23. The method of claim 19 wherein,

said step of positioning a prismatic film between said light source and said polarizing layer includes forming a plurality of facets on a surface of a polymeric film, said facets defining a plurality of parallel grooves extending in a direction perpendicular to said preferred polarization axis.

24. The method of claim 19 wherein,

said step of positioning a prismatic film between said light source and said polarizing layer includes forming a plurality of symmetrical facets on a surface of said prismatic film.

25. The method of claim 19 wherein,

said step of orienting said prismatic film relative to said polarizing layer includes identifying said preferred polarization axis of said prismatic film.

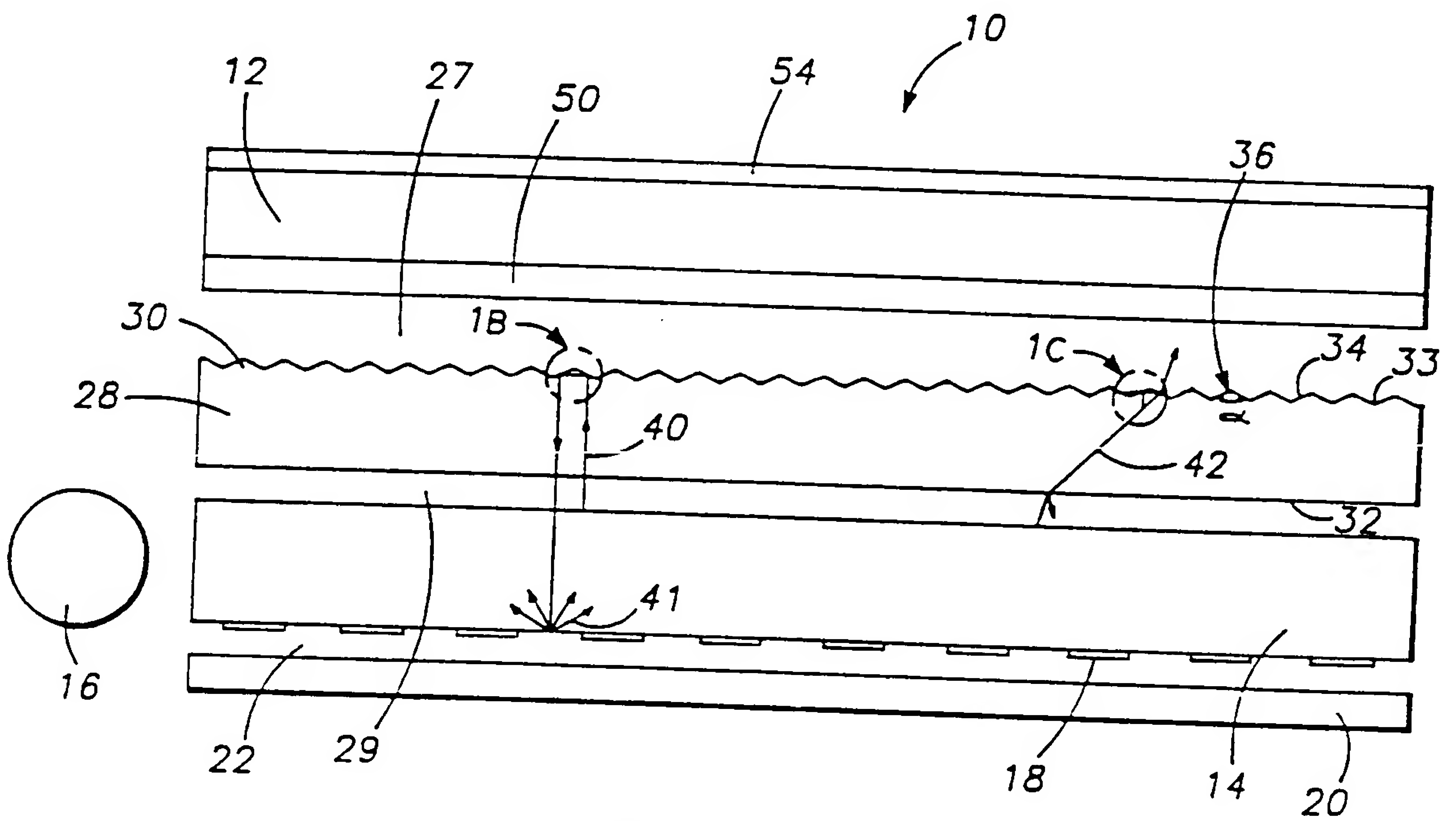

FIG.—1A

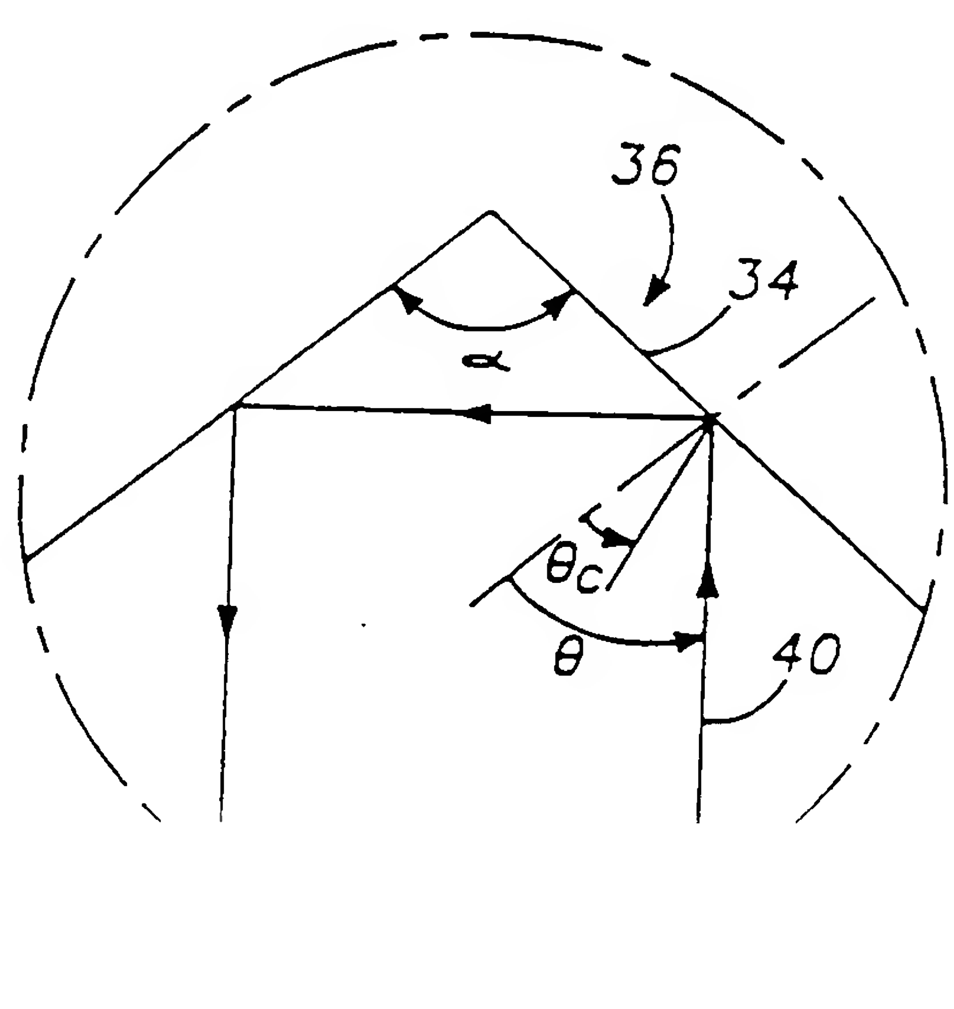

FIG.—1B

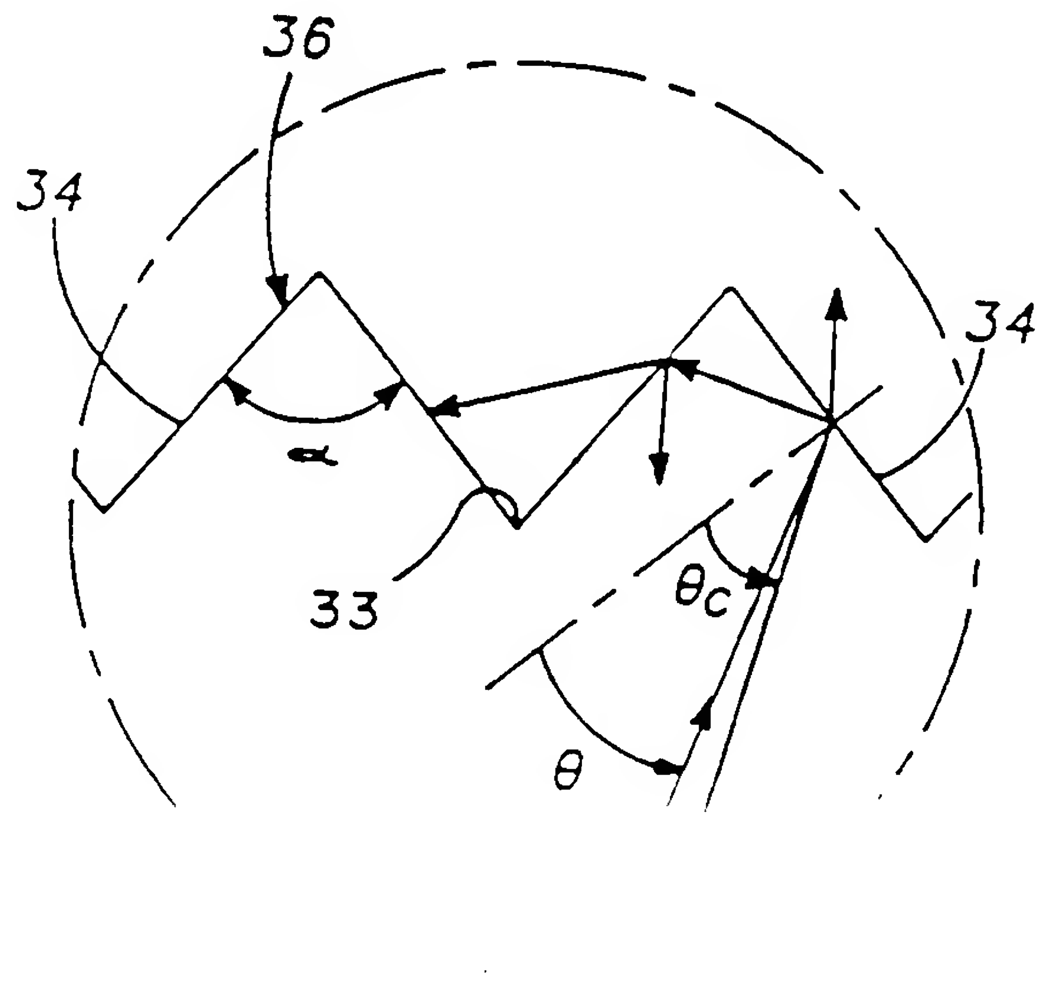

FIG.—1C

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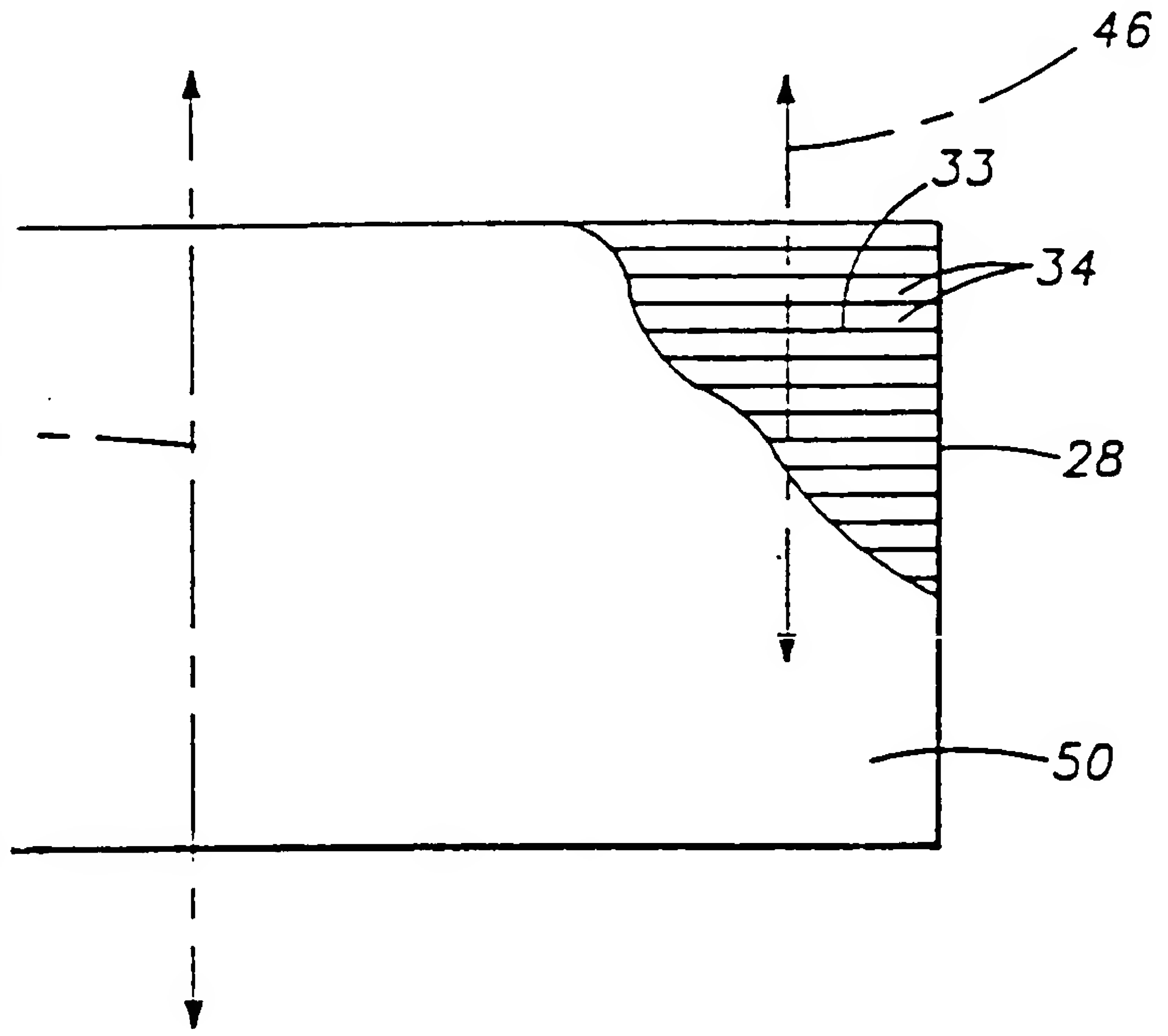

FIG.—2

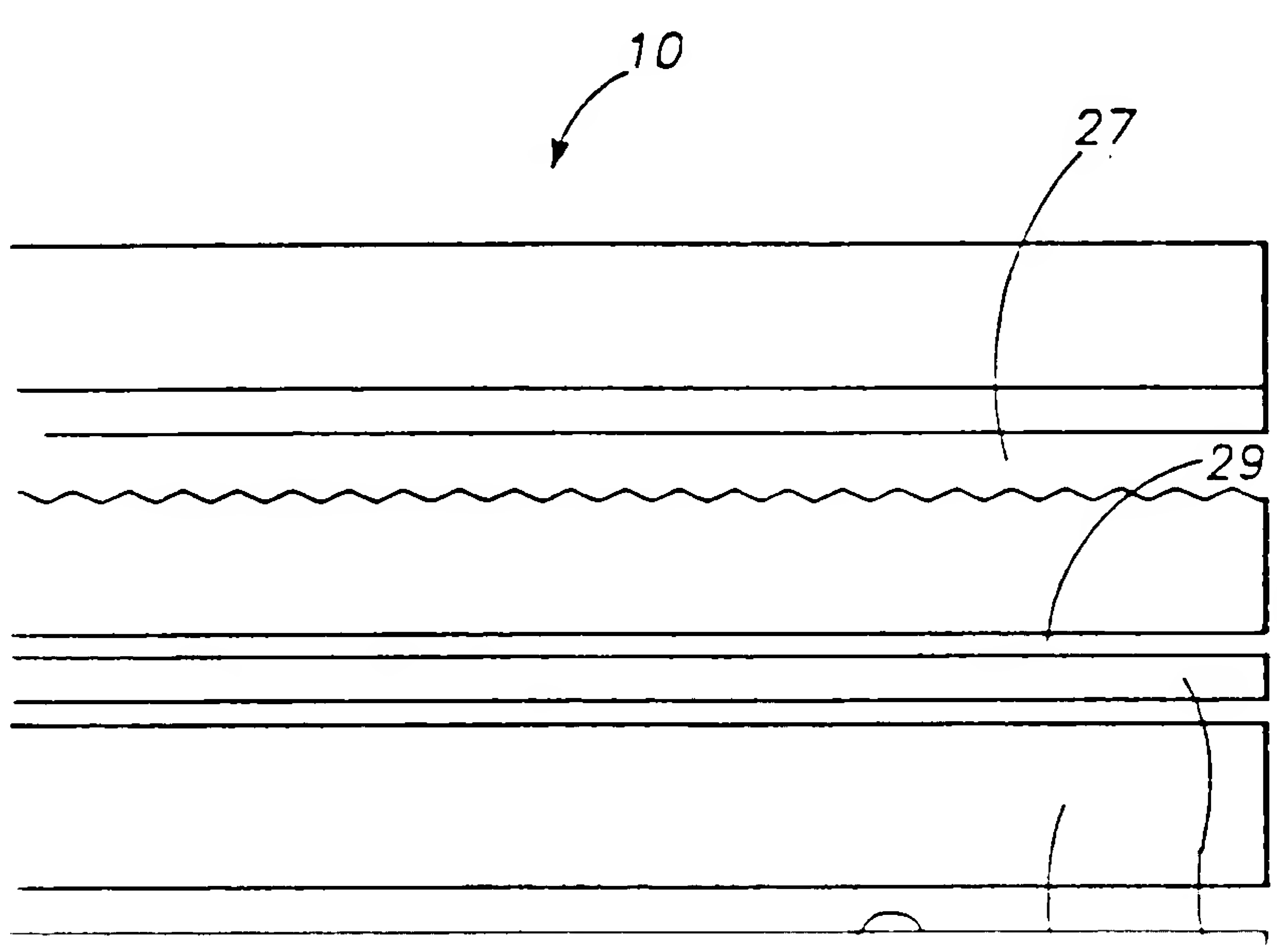

FIG.—4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 94/05936

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 G02F1/1335 G02B5/30 F21V9/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 G02F F21V G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IBM TECHNICAL DISCLOSURE BULLETIN, vol.33, no.1B, June 1990, NEW YORK US pages 143 - 144 'polarized backlight for liquid crystal' see the whole document ---	1-5, 11-25
Y	EP,A,0 531 939 (ENPLAS CORP) 17 March 1993 see column 4, line 35 - column 8, line 16 ---	1-5, 11-25
Y	SID INTERNATIONAL SYMPOSIUM .DIGEST OF TECHNICAL PAPER, vol.23, 1992, USA pages 427 - 429 M.F.WEBER 'RETROREFLECTING SHEET POLARIZER' see the whole document --- -/--	1-5, 11-25

[X] Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search: 27 September 1994

Date of mailing of the international search report: 14. 10. 94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,3 349 238 (M.KRUGER) 24 October 1967 see column 2, line 21 - column 4, line 09 ---	1-5,9-25
A	PATENT ABSTRACTS OF JAPAN vol. 17, no. 147 (P-1508) & JP,A,04 318 534 (K.JIYOUJI) 10 November 1992 see abstract ---	1,13,19
P,X	PATENT ABSTRACTS OF JAPAN vol. 18, no. 223 (P-1729) & JP,A,06 018 873 (FUJITSU) 28 January 1994 see abstract ---	1-5,9-25
P,X	EP,A,0 597 261 (ASAHI GLASS) 18 May 1994 see page 5, line 15 - page 8, line 58 -----	1-5,9-25

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INTERNATIONAL SEARCH REPORT

Info. ation on patent family members

International application No.
PCT/US 94/05936

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0531939	17-03-93	NONE	
US-A-3349238		NONE	
EP-A-0597261	18-05-94	NONE	